Fibre Reinforced Plastic Concepts for Structural Chassis Components

Gundolf Kopp,
Oliver Deisser,
Prof. Dr. Horst E. Friedrich

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DLR & Institute
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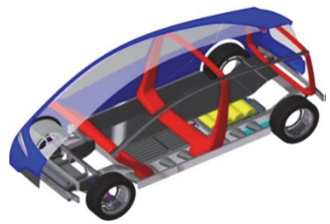
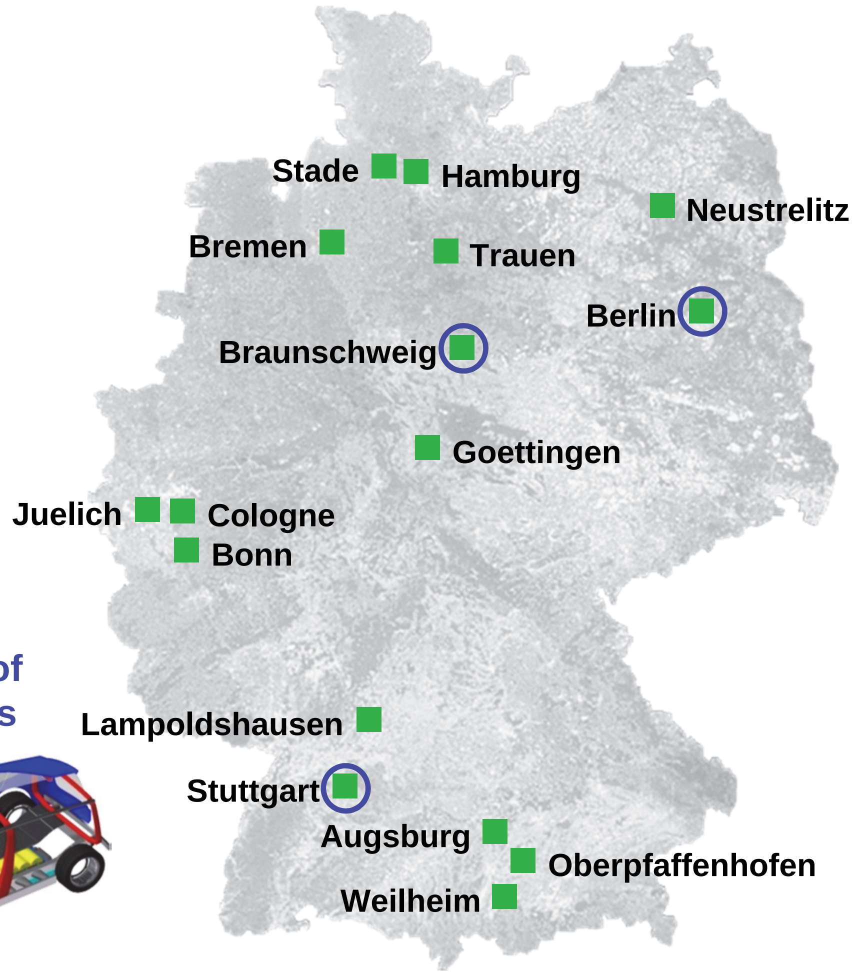
Locations and employees

7400 employees across
32 institutes and facilities at
16 sites.
Offices in Brussels,
Paris and Washington.

Research Areas:
- Aeronautics
- Space Research and Technology
- ***Transport***
- Energy
- Space Administration
- Project Management Agency

DLR & Institute of
Vehicle Concepts





Mass reduction for decreasing the running resistance

Equotation of motion:

$$\Sigma F_w = \underbrace{m_g \cdot g \cdot f_R \cdot \cos\alpha}_{F_R} + \underbrace{r_L \cdot A \cdot c_w \cdot v^2/2}_{F_L} + \underbrace{b \cdot (m_g + \Sigma m_{rot})}_{F_B} + \underbrace{m_g \cdot g \cdot \sin\alpha}_{F_{St}}$$

$$\Sigma F_w = F_R + F_L + F_B + F_{St}$$

~35% ~25% ~40%

~75% = F(m)

⇒ Reducing the need for energy by reducing mass:

- Within the system boundary chassis suspension:
  - Mass of wheelmount, control arm,…
  - Mass of springs, dampers,…
- With inclusion of other subsidairy systems (eg. drivetrain):
  - Wheel integrated or wheel close engine

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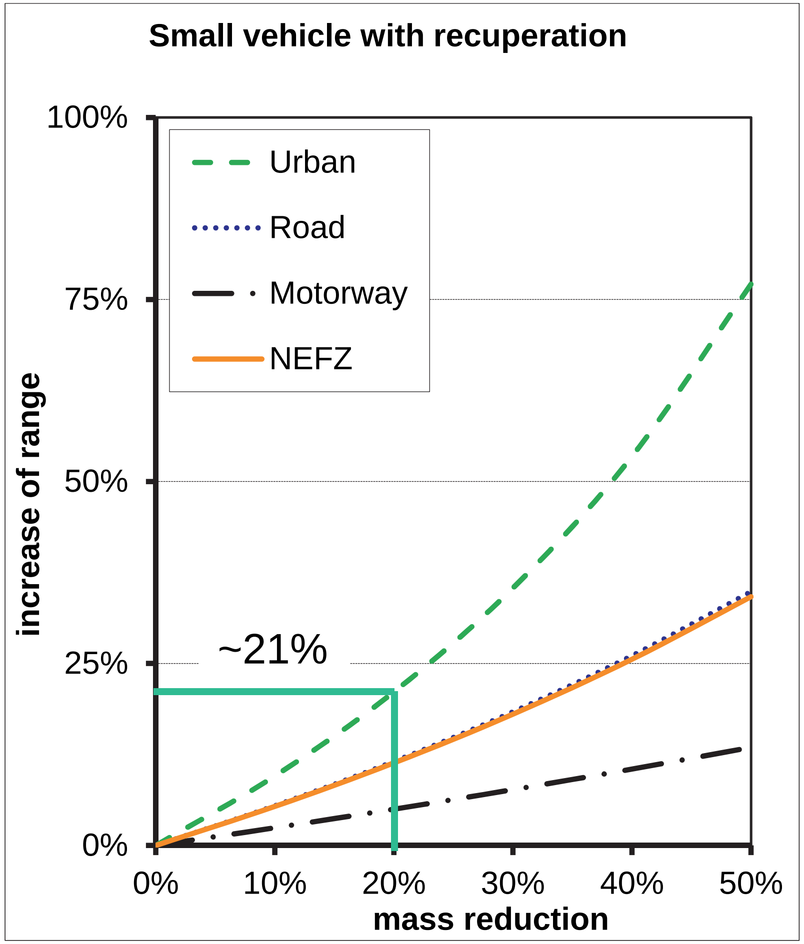
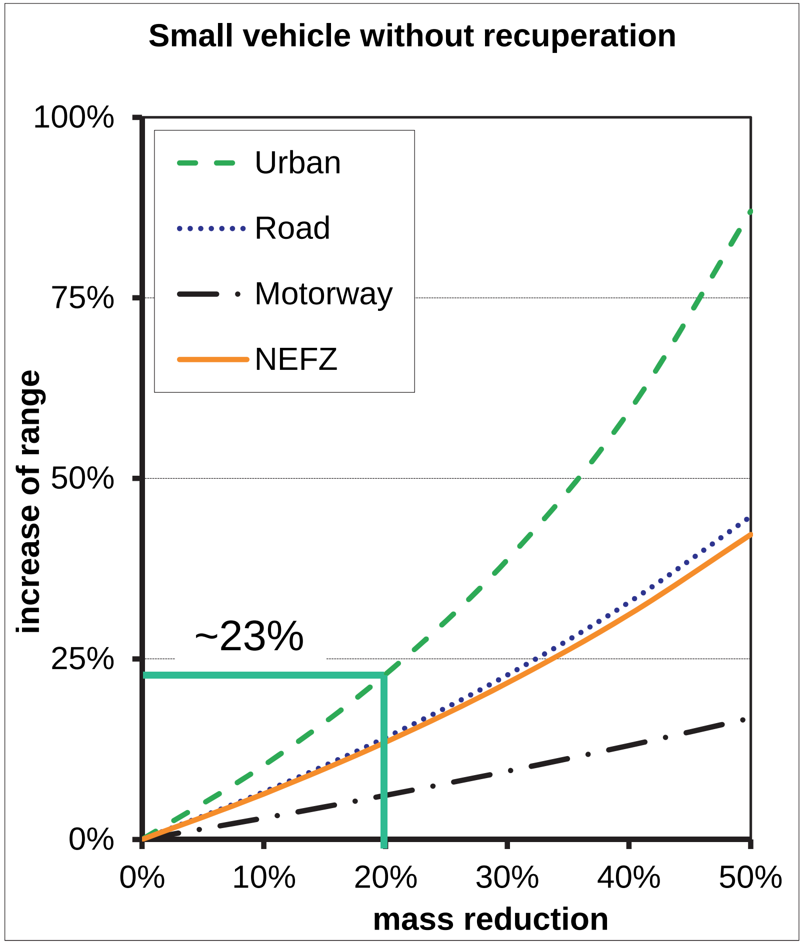
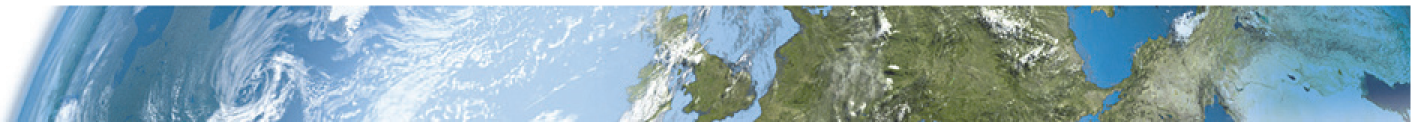
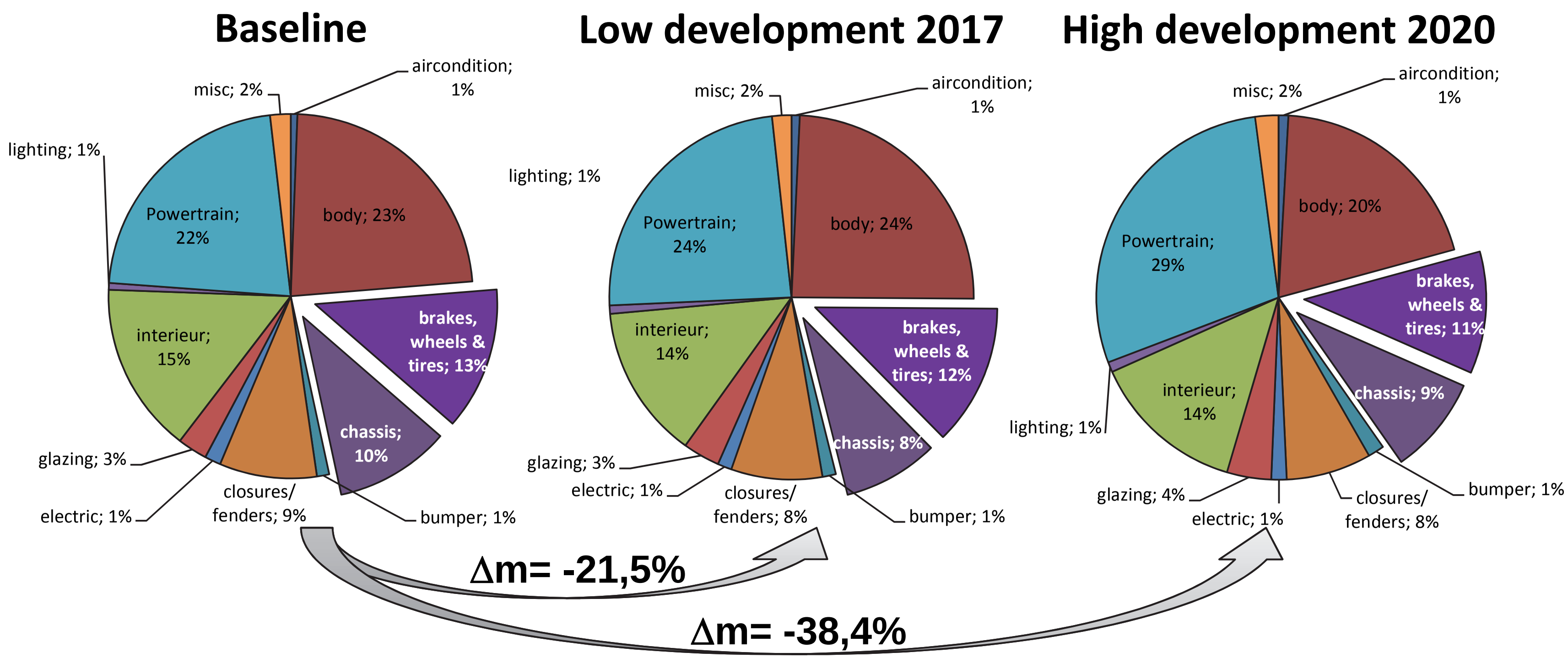
Increase of range by mass reduction







Mass distribution in the vehicle



Reference: Toyota Venza $\Delta m_{suspension}$= -27% $\Delta m_{suspension}$= -43%

⇨ No verification of the results
(neither by simulation nor by testings)

Source: "An Assessment of Mass Reduction Opportunities for a 2017 – 2020 Model Year Vehicle Program"; Lotus Engineering Inc. [2010]

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Lightweight design strategies

Step 1

Requirements, Conditions and Standards

- Law
- Customer and Market
- CO2-Strategy

Step 2

Concept

- Package
- Integration
- Modularisation
- Technologies

Step 2.1

Materials

- Materials
- Surfaces
- Processes

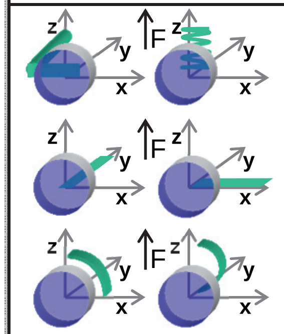
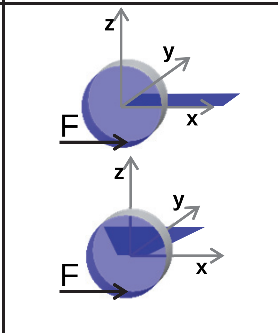
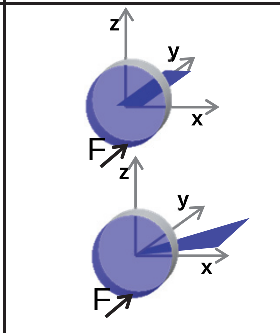
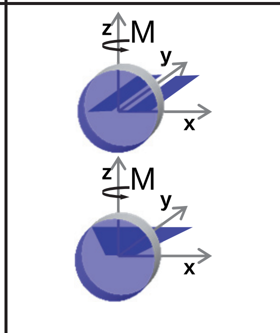
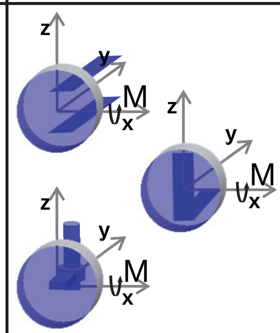
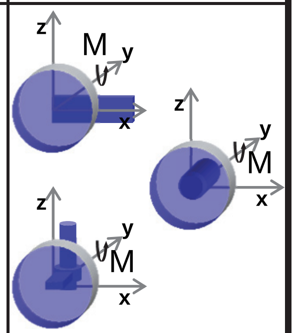
Step 2.2

Design

- Shape
- Geometry

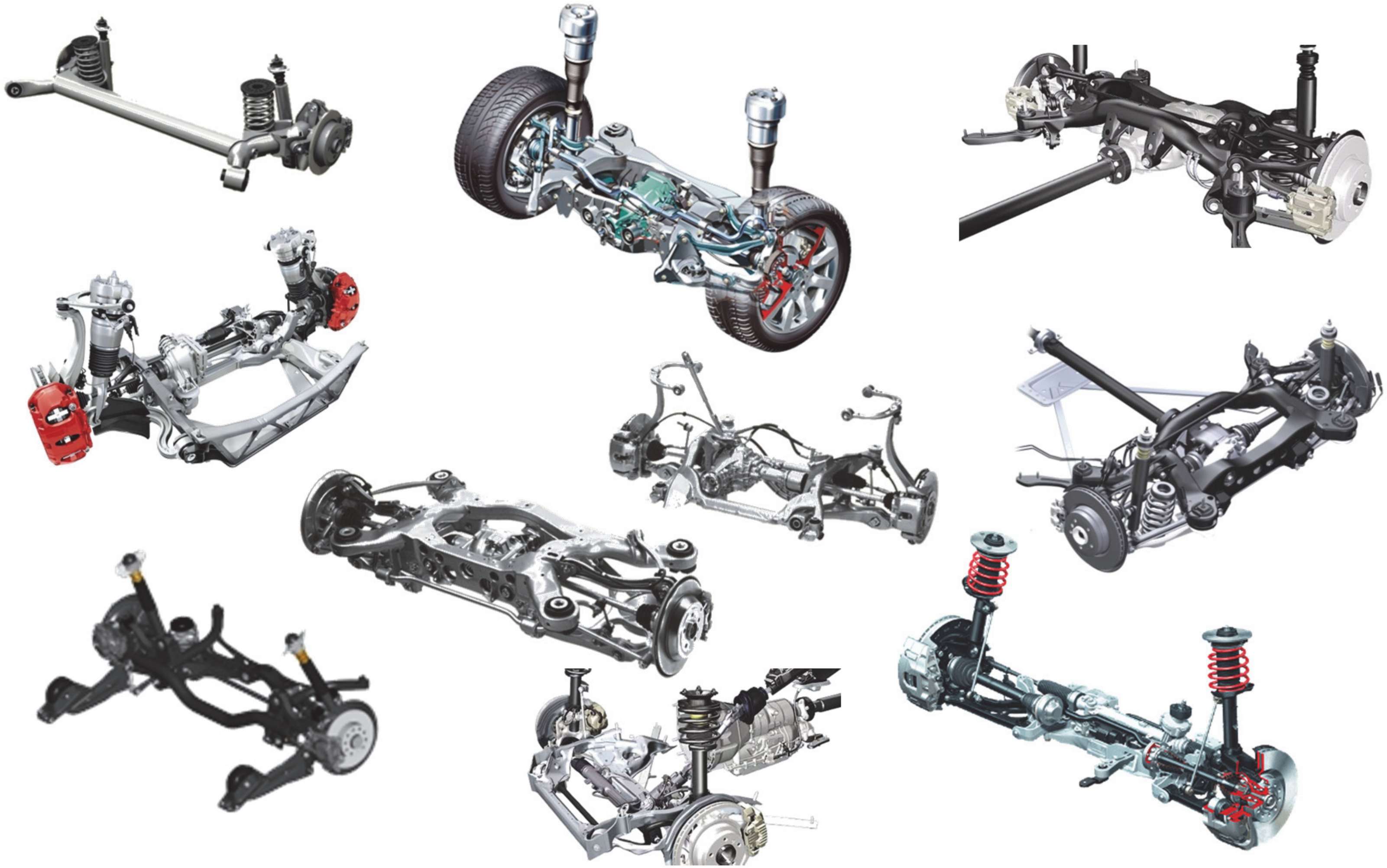
Source: Haldenwanger (1997)
DLR (2007)

The six requirements of the chassis suspension

Vertical flexibility	Longitudinal stiffness	Transverse stiffness	Precise toe-in	Camber stiffness	Support of braking force
					
– Torsion spring, coil spring – Traverse, longitudinal leaf spring – C-shaped spring	– Trailing link – (unequal length) A-frame arm, stiff triangle structure	– Transverse arm – Semi-trailing arm, stiff triangle structure	– 2 horizontal arms – (unequal length) A-frame arm, stiff triangle structure	– 2 vertical transverse arms – stiff triangle structure – Vertical guidance	– Long-short arm (sword) – Torsion bar – Vertical guidance

Source: ZF Friedrichshafen AG

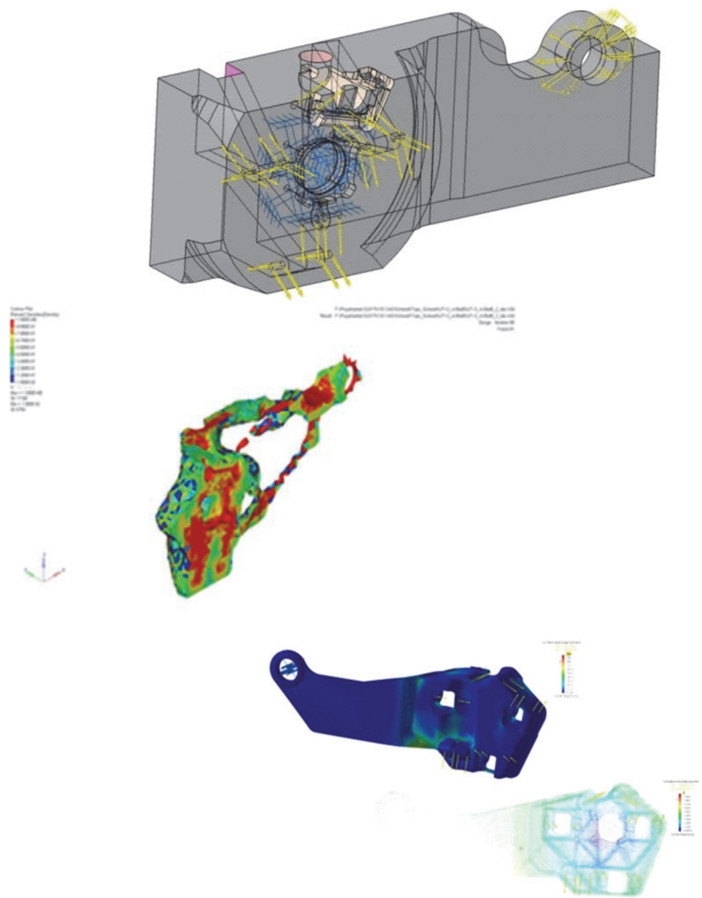
Overview in conventional chassis suspensions



Sources: BMW AG; Volkswagen AG; ZF Friedrichshafen AG; www.911erclub.com; www.auto-treff.com

FRP lightweight design in chassis suspensions

Concept design of a long-short arm (sword)

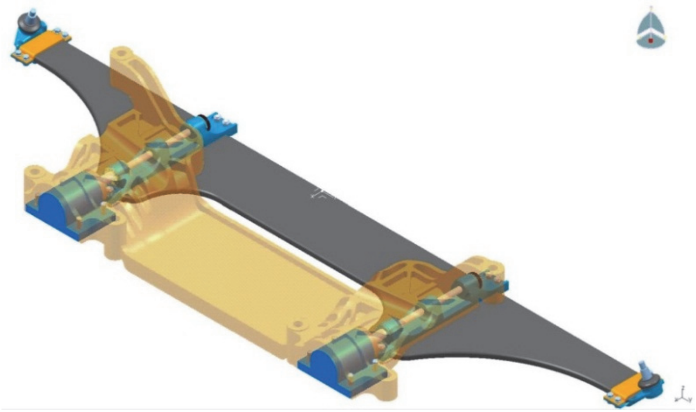


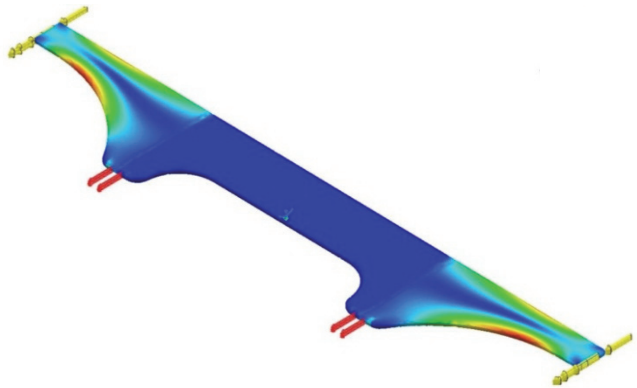
Development chain of a long-short arm concept design in FRP:

- Definition of the design space and boundary conditions
- Design of the topology model and definition of the loads
- Simulation and interpretation of the results
- Concept design of different variants
- Draft simulation of the variants with different material data
- Rating of the variants

FRP lightweight design in chassis suspensions

Concept design of a MacPherson front suspension





Aim:

concept design of a MacPherson front suspension with a traverse leaf spring

Approach:

- Detection of design space and the reference parts
- Analytical dimensioning of the traverse leaf spring
- Concept design of the traverse leaf spring
- Concept design of the subframe
- Draft simulation of the parts for evaluation of the concept

Result:

- Mass reduction by 26%

FRP lightweight design in chassis suspensions

chances and risks

Reasons for not applying known concepts in series production:
- Up until now elaborative manufactoring processes
- Lacking confidence in FRP
- Complex simulation methods because of anisotropic behaviour
- No existing databases for FRP materials

Potential for comming developments:
- Optimization of large-volume production of FRP
- Optimization of simulation tools
- Build up of material databases

By verification of generic parts

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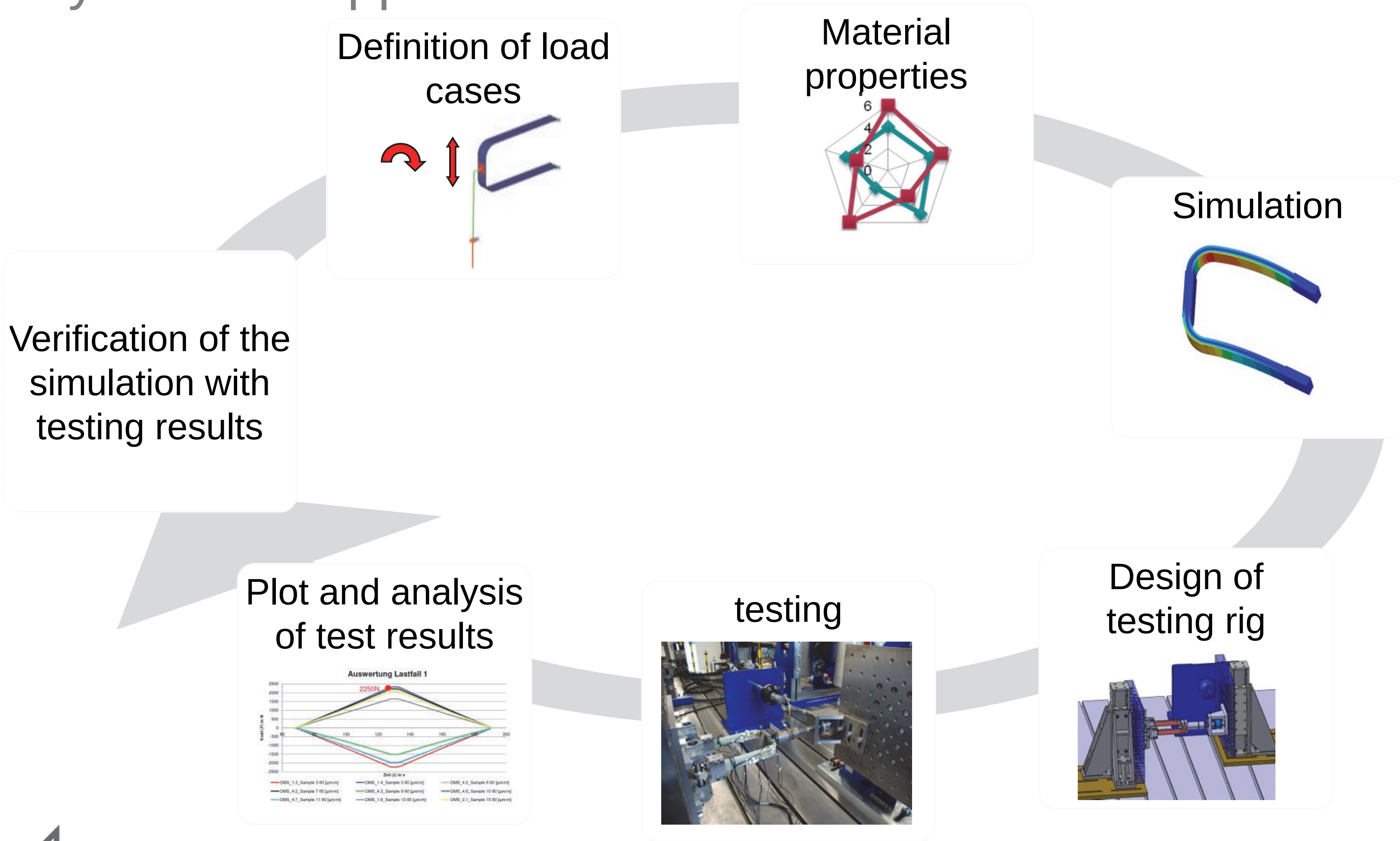
Verification of generic parts in FRP

systematic approach at BMBF-ALF



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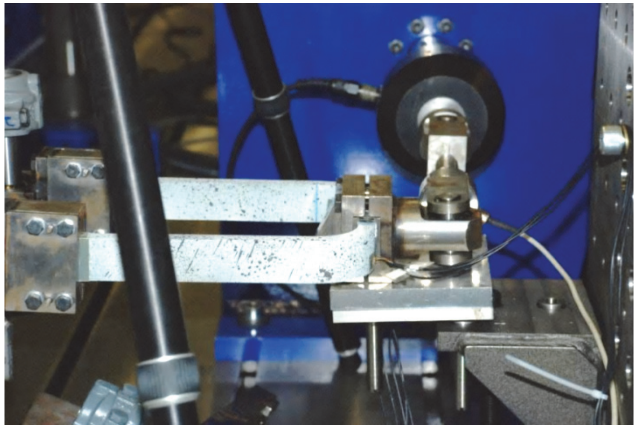
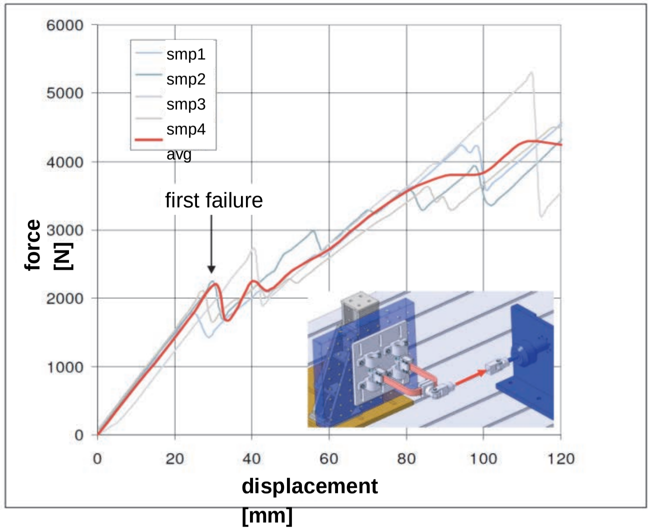
Verification of generic parts in FRP at an example

workpackages form BMBF-ALF done at DLR

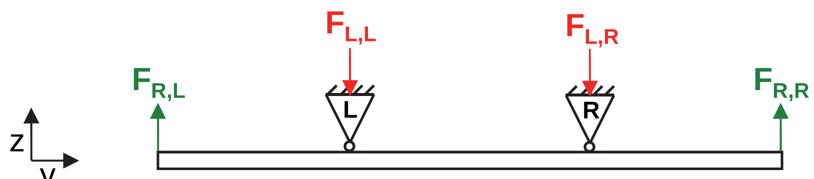


- Design and dimensioning of testing rig
- Nondestructive analysis by CT
- Testing of generic parts
- Plot and analysis of test results

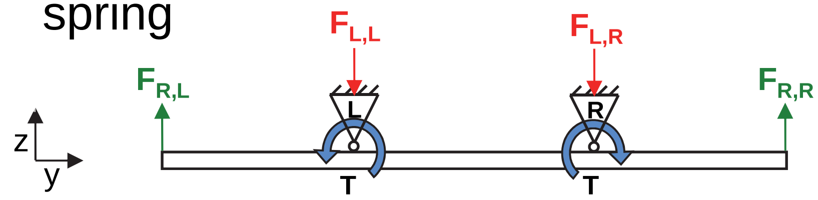


Possibilities in activating functions in chassis suspension

Traverse leaf spring:



active bearing of a traverse leaf spring



- Use of active systems to change the spring rate
- Simplest way: block the rotational degree of freedom
  - Traverse spring leaf behaves like two independent short spring leafs
  - Increase in spring rate

Example for Change of spring rate	Without active system	Blocking of rotation
Equilateral load	19,8 N/mm	98,9 N/mm
alternating load	42,4 N/mm	98,9 N/mm

Development of drive-train/vehicle concepts for the individual mobility for tomorrow´s needs

Probable concepts for tomorow:

- Universal Vehicle:
  range <600km, CI engine
  (start of fuel cell),
  ability for zero emission >~50km
  (with hybrids, Generally with FC)
- Long-Distance Vehicle:
  Range <1000km, CIE-Hybrid (pos. FC), no zero emission
  (with Otto-Hybrid)
- City Vehicle:
  Rage <200km zero emission modus, electric traction, batteries, Range Extender

Subsequent concepts:

- New Generation Car:
  Range <1000km, CIE-Hybrid and Fuel Cell,
  ability for zero emission <100km
- City Vehicle:
  Range <300km zero emission modus, electric traction, batteries

- New concepts of Use, Ownership and business model

Conclusion for the chassis suspensions of the future:

- Application Universal / Long-Distance Vehicle
  - Demand for vehicle dynamics, comfort and safety will be preserved respectively will increase
  - Efficency will be gained by low specific mass and where aplicable recuperation of energy
- Application City Vehicle
  - Demand for vehicle dynamics and where applicable comfort will be adappted;
safety standards must be preseved
  - Efficency will be gained by low specific mass and where aplicable recuperation of energy

Automobile mobility persists to be a success model

Many thanks!

ZF

KOMPETENZ ZENTRUM | FAHRZEUG LEICHTBAU

3B the fibreglass company

DSM

IFB Institut für Flugzeugbau

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